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Lubrication

A Technical Publication Devoted to
the Selection and Use of Lubricants

THIS ISSUE

LUBRICATION
OF OIL FIELD
MACHINERY

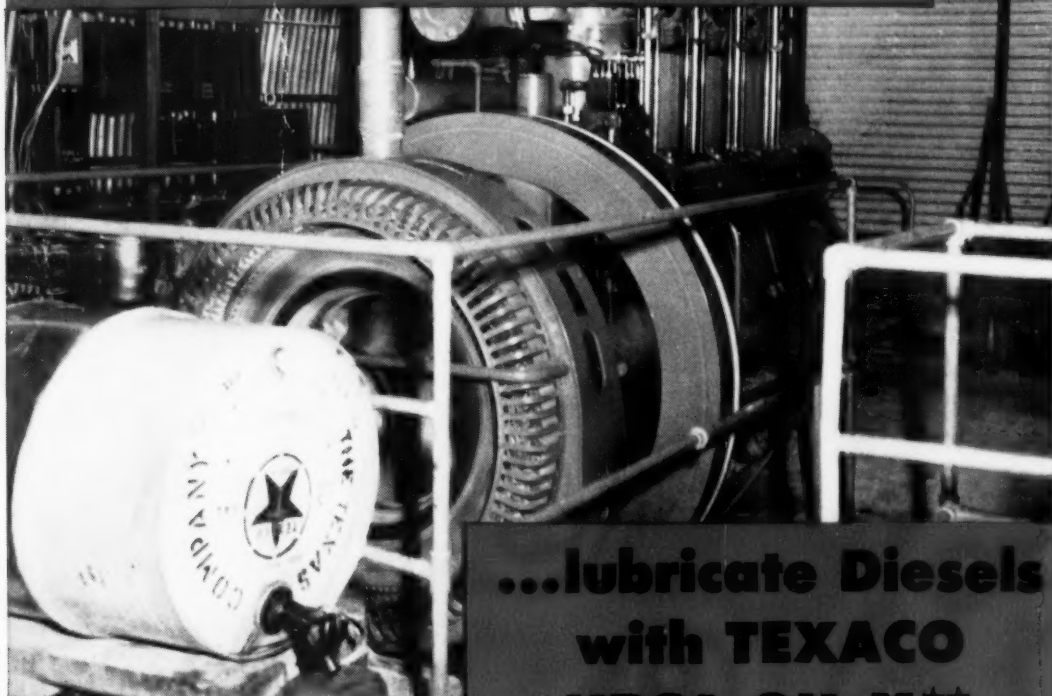


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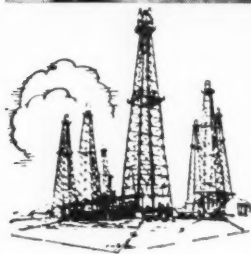
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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of Oil Field Machinery

OIL FIELD DRILLING dates back to the Drake well in 1859. In those days the cable tool rig served both as a drilling and pumping unit. The rotary rig came later. It was used by Captain Lucas at Spindletop, and thereafter with but few changes until the 1920's except that in the meantime parts were made bigger and stronger. Most of these changes were suggested by drillers and other oil field people. Engineering development came into the picture when deeper drilling required heavier equipment, and designing on a strength-for-weight basis. Credit is due to the engineering organizations of the oil field tool manufacturers who appreciated the merits of high strength alloys; precision fits; high standard integral parts such as roller chains, ball bearings and cut herringbone gears; dust and weather-tight housings; and adequate structures to assure proper alignment of parts. All these improvements have become standard during the past thirty years.

Along with these advances in rig design came the endeavors to develop maximum power and better utilization of the available fuels—crude oil and natural gas—in oil field engine operation. The natural sequence was greater respect for lubrication.

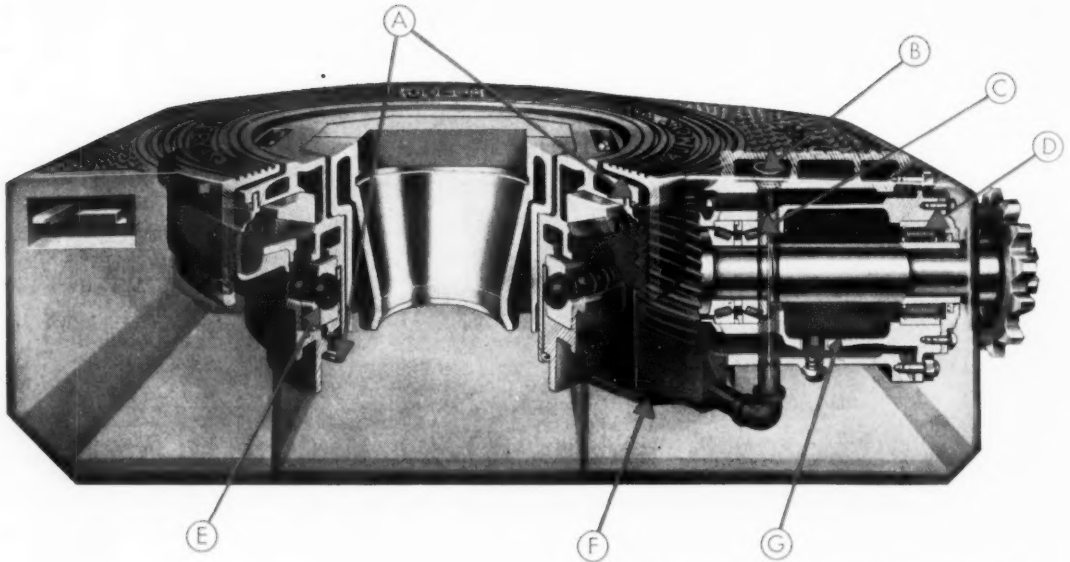
When steam was the only source of motive power, lubrication was not given much thought. The familiar tallow pot decorated most steam chests. An oil can comprised the rest of the lubricating equipment. In effect, lubrication was re-

garded as an unwelcome necessity. The petroleum chemist was still to come and petroleum as such was the source mainly of kerosene. Lubricating oil cuts followed, when it was realized that machinery could be lubricated more effectively with petroleum oils than the animal or vegetable oils of the day, which had such a tendency to oxidize and gum.

Lubrication of oil field machinery also gained more respect when the internal combustion engine became a factor in drilling and producing, and precision bearings and gearing were assembled in the design of pumping units. Enclosed gears, ball and roller bearings, and link-type chains played an important part in the development of dependable machinery.

Oil field operations as the initial stage in the production of petroleum products deal with the raw material in fluid bulk form. Crude oil is not conducive to cleanliness. Even so, that should not lead to the idea that lubrication is unimportant as applied to the machinery required for production or handling to the refineries. In fact, quite the opposite, because most of this machinery must operate continuously, exposed to the weather and considerable possibility of lubricant contamination.

The builders of oil field machinery realize the value of effective lubrication. They know the extent to which it prolongs the life of machine parts and reduces maintenance costs. Evidence of this realization is indicated by the thought which is given to building provision for lubrication into



Courtesy of IDECO Division — Dresser Equipment Company

Figure 1—Sectional view of an IDECO streamlined rotary table. A—indicates the neoprene mud seals; B—the point for introduction and gauging of lubricant; C—the double-tapered roller bearing which takes the thrust which originates at the pinion and carries the radial load; D—the roller bearing which carries the sprocket end of the pinion shaft. This is fitted with an oil seal; E—the main bearings which are hardened steel balls; F—the low reservoir oil sump which traps foreign matter and keeps it away from the bearing surfaces; and G—the auxiliary oil reservoir in the pinion housing. This holds an adequate supply of oil to lubricate the pinion bearings; it also serves as a safeguard in case oil in the main reservoir drops below the normal operating level.

modern designs. To keep this machinery functioning dependably the operator must be just as careful in seeing that it is properly lubricated in service.

THE REQUIREMENTS FOR POWER

Power is necessary to operate oil field machinery from the time the rig starts to drill until the pool is exhausted or pumping no longer is economical. The oil itself (or the gas) is the source of this power. When machinery was driven primarily by steam engines the oil was burned under steam boilers to generate the required steam. This involved the water supply; sometimes this was not too dependable or too clean. So when internal combustion engines became available the diesel or gas engine began to supplant steam. Here again the oil or gas from the field furnished the source of power although it was burned in a different type of combustion chamber.

Oil field engines do not differ materially from those designed for industrial service. The theory is identical; also they look very much the same. In service however they usually function under conditions which are more severe, so maintenance is a more difficult procedure. As a result a heavy load is imposed upon lubrication and engine lubricants. It means that these oils may have to work under

overload some of the time. In steam pump and engine service the nature of the steam is the criterion. In the diesel or gas engine, fluctuations in atmospheric temperatures along with high dust-content in the air and possible difficulty in engine cooling may have a definite effect upon engine performance if lubrication is not carefully considered.

The power developed by the oil field engine operates the drilling rig; the draw works; the slush or mud pumps; the oil well pumps which deliver the oil to the surface; and later the pumping units in pipe line service.

The drilling is done by:

- (a) Percussion (with cable tools) or
- (b) Rotary methods

Derricks are required for both as well as for any of the recent modifications or combinations of these systems.

CABLE-TOOL DRILLING

Cable tool drilling as developed in the early days of the oil industry was effective when the fields involved hard dry strata such as shales, limestones and calcareous rock formations. It was also found to be well adapted to shallow well drilling, a fact

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which led to the use of the less-costly portable unit for drilling test holes. In cable drilling a bit or heavy sharpened tool is periodically lifted and dropped against the strata to be drilled, to break or crush its way through by impact. The cuttings or crushed materials are removed by means of a bailer or long tube which is periodically lowered into the hole.

In this type of percussion drilling, power is transmitted directly from the engine to the band wheel. The shaft of this wheel is mounted on sleeve bearings, with two chain sprockets and a rope sheave on one end and a crank on the other. This crank drives the walking beam which operates the drill bit through a connecting rod known as the pitman. One of these chain sprockets also drives the sand reel for the bailer, the other operating the calf wheel which is used to handle the pipe or casing. The rope sheave drives the bull wheel which is used to raise or lower the drill bit. This applies to older equipment as still in use; more modern cable tool rigs are of all steel construction equipped with chain drives.

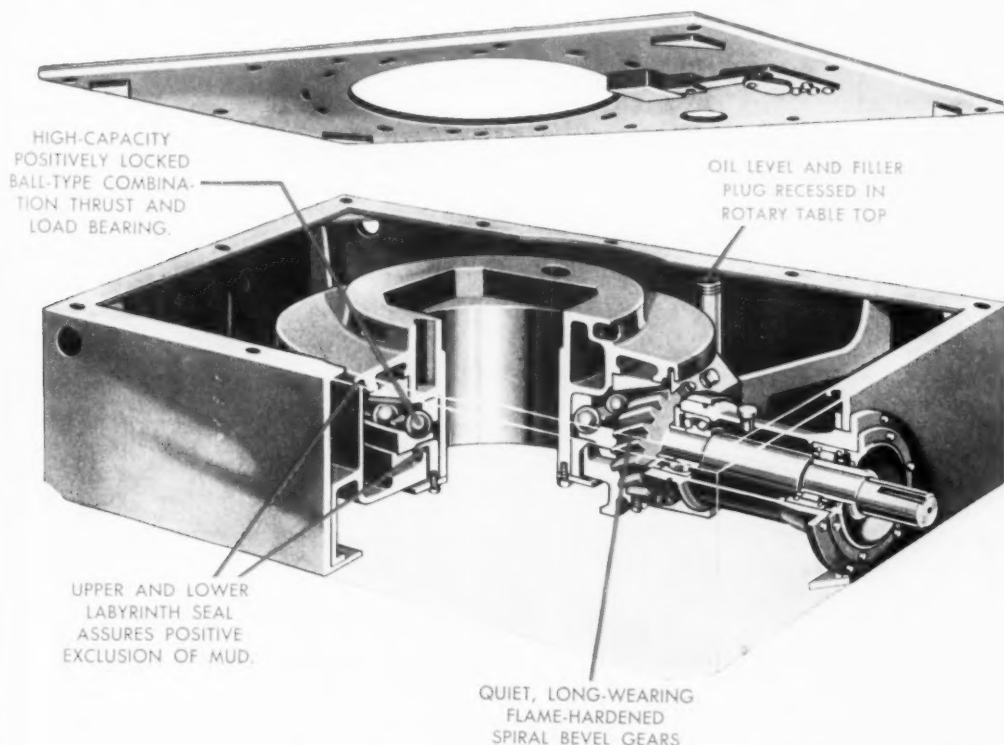
The speed of the bull wheel controls the speed at which the tools are let into the hole. The brake

which regulates the speed of the wheel is usually a steel band with provision for water-cooling to prevent overheating during rapid running of the heavy tools in the hole.

ROTARY DRILLING

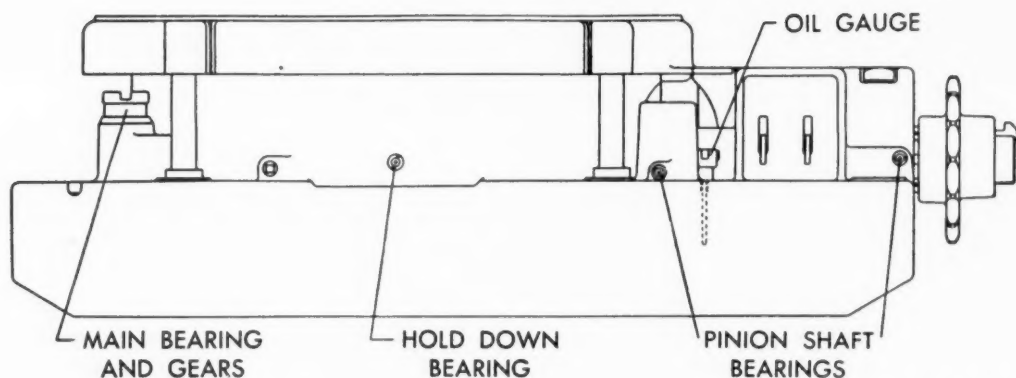
Rotary drilling has almost completely replaced cable tools which are definitely limited as to depth. Rotary drilling is preferred for deep wells and when dealing with soft, damp or relatively wet rock formations which cave readily, or where high bottom hole pressures are encountered. Rotary drilling is carried out by rotation of the bit attached to the drill pipe. This latter is heavier than ordinary well casing, resistant to twisting, and capable of withstanding high pressures and impact loading.

Rotary drilling requires no bailing mechanism as it usually is carried out in the presence of drilling mud which serves to wash out the cuttings, cool the auger-like edges of the bit during drilling, and hold back the water or hydrocarbons in the formations being penetrated. This is accomplished by pumping the mud down the hollow drill pipe,



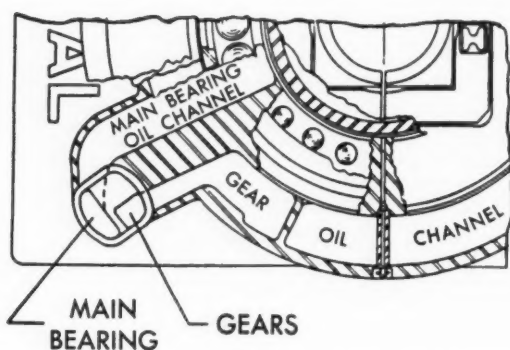
Courtesy of Emsco Manufacturing Company

Figure 2—Structural details of the EMSCO type O Rotary showing those parts related to the lubricating system. All working parts are flood lubricated from the central oil reservoir except the pinion shaft which is hand lubricated.



Courtesy of The National Supply Company

Figure 3—Side view of an IDEAL rotary machine indicating parts related to lubrication.



Courtesy of The National Supply Company

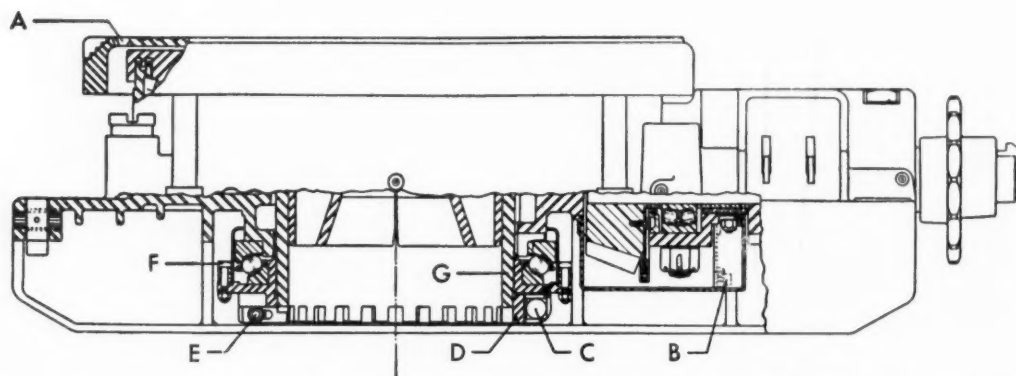
Figure 4—Top view of an IDEAL rotary (Serial No. T-947) showing oil channels. The same oil is used in both reservoirs.

through nozzles in the end of the bit and back to the surface through the space between the pipe and wall of the hole.

The Draw Works

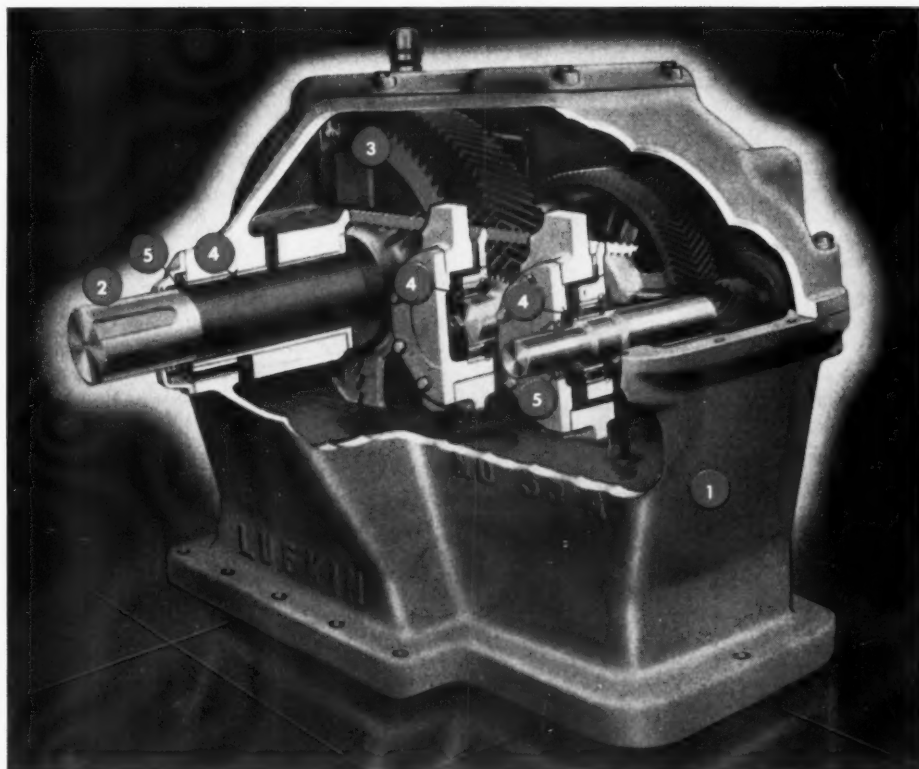
The hoist or winch mechanism which is used in rotary drilling is termed the draw works. Some are driven by shafts and gears, others are connected to the engine by a sprocket and chain connection. The design will dictate how the connecting mechanisms are arranged. Chain drives are being more and more widely used here as well as on mud pumps. The hoisting drum handles the steel wire cables which connect the crown and travelling blocks.

In modern deep well drilling, loads may be severe, units being designed today to handle safely



Courtesy of The National Supply Company

Figure 5—Cut-away side view of an IDEAL rotary showing at A—the holes through which water is directed to keep the space between the table guard and side of base free of mud; B—the oil reservoir drain plug; C—the clamp bolts on the hold-down bearing adjusting ring "D"; E—the locking nut key bolt; F—other hold-down bolts; and G—the gear table.



Courtesy of Lufkin Foundry & Machine Company

Figure 6—The LUFKIN gear box lubrication system. 1—indicates the reducer housing; 2—the forged alloy steel shaft; 3—the precision cut herringbone gears; 4—the bronzoid crankshaft bearing, and Hyatt Hy-load roller bearings on the pinion shafts; these latter (see 5) are equipped with patented oil seals. The main crankshaft is equipped with collar oil slingers and annular grooved drain covers. Oil bath and coverage of gears is clearly shown in red.

upward of 500 tons working load. These loads will react upon shaft bearings and chain connections. For this reason roller bearings are widely used on modern oil field drilling equipment. They can be lubricated by either oil or grease according to the housing and manner of sealing. A 300 to 600 second viscosity mineral oil functions satisfactorily in an oil-tight housing. Whenever there is possibility of leakage, however, the bearings can be equipped with pressure gun fittings and lubricated with a high quality grease.

Operating Procedure

Rotary drilling is accomplished through a shaft or a power take-off chain from the draw works. The principle involved in turning the rotary table (which turns the drill pipe) is much the same as that employed in the rear axle and differential assembly in automotive service. This is accomplished by a bevel pinion and ring gear drive in

the rotary, which is located on a sturdy foundation at the level of the derrick floor.

The weight or thrust load of the drill string is usually carried by the rotary table which is mounted on ball or roller bearings lubricated from an oil reservoir around the lower race. Similar bearings may also be used to carry the pinion shaft.

Housed Gears Are Most Effective

Gears, pinions and their respective bearings are lubricated according to the installation and type of housing. Where gears are exposed and subjected to water and dust, a comparatively heavy gear lubricant of from 1000 to 2000 seconds Saybolt viscosity at 210 degrees Fahr. should be applied periodically to the tooth surfaces. A cut-back material also is suitable where ease of application is desired. With such a product the solvent evaporates to leave a protective film similar to that which would be furnished by the heavier product.

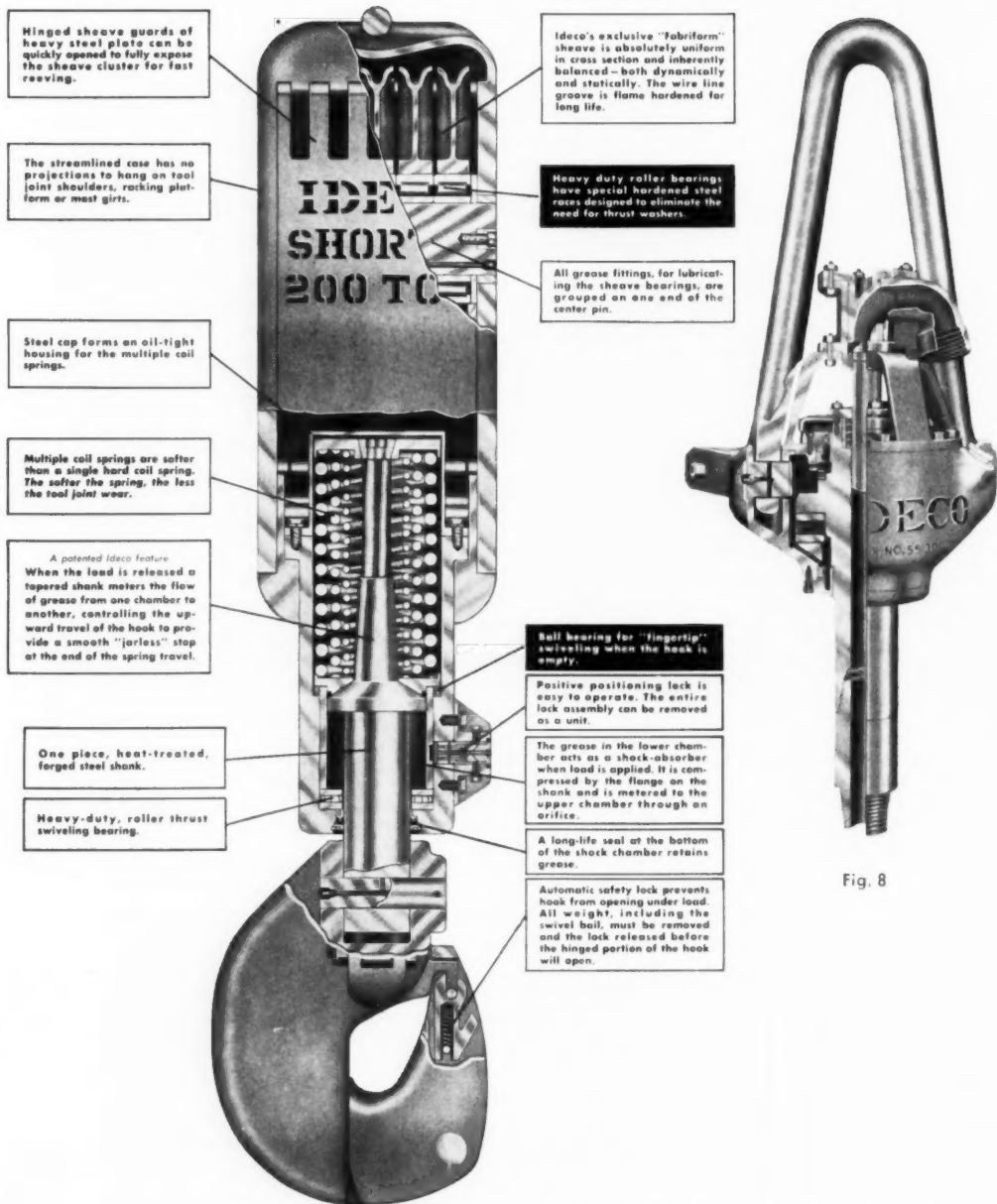
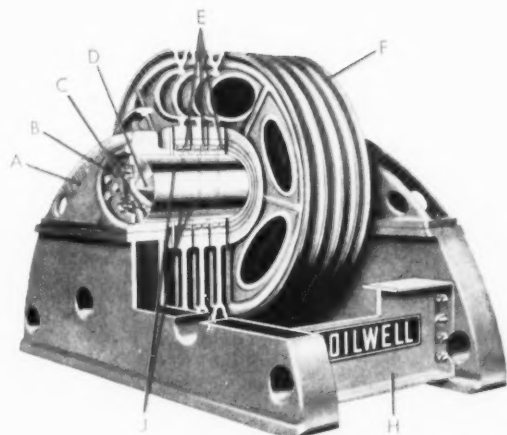


Fig. 8

Courtesy of IDECO Division - Dresser Equipment Company

Figure 7 and 8 — Showing constructional details of the IDECO Shorty block (Fig. 7); and cut-away of an IDECO streamlined swivel (Fig. 8). Lubricant provisions for the main and alignment bearings of the swivel are shown in red. The black boxes for the Shorty block indicates the heavy duty roller bearings and ball bearings.

LUBRICATION



*Courtesy of Oil Well Supply Division
United States Steel Corporation*

Figure 9—Details of an "OILWELL" No. 500 Crown Block showing A—center pin support; B—center pin end plate; C—grease fittings; D—center pin; E—sheave roller bearings; F—sheaves; H—base; and J—sheave bearing grease passages.

On the other hand, the modern rotary as built today has its table bearings, gears and pinions fully enclosed in a unit casing, the bottom of the table forming the oil reservoir. Under such conditions the one lubricant can be used for all elements, being circulated by the gear teeth or a pump. The choice of lubricant must depend upon the tightness of the housing; usually a heavy automotive gear lubricant will function satisfactorily, although some will prefer a heavy motor oil of around the S.A.E. 60 range.

Blocks

Other equipment incident to rotary drilling includes the crown and travelling blocks through which the cable is strung to develop the required leverage.

The crown block is anchored securely at the top of the derrick. With its companion travelling block, it carries the steel cable attached to the hoisting drum on the draw works. Each block is fitted with a number of sheaves over which this cable is passed in conventional pulley-block arrangement to give the necessary lifting power.

Crown and travelling blocks usually are mounted on bearings of similar type so that they will be completely interchangeable. Either bronze-bushed sleeve type bearings or roller bearings can be employed. Grease lubrication at regular intervals by pressure gun is applicable using a grease containing an oil of comparatively high viscosity.

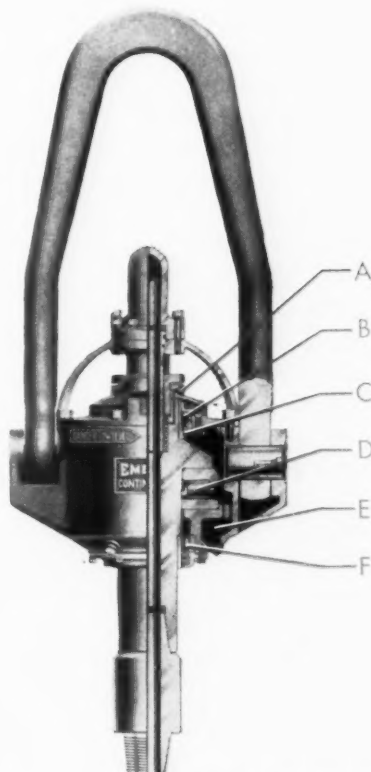
The Swivel

The swivel, which enables free rotation of the

drill pipe, is located below the travelling block, being suspended from the casing hook by a bail or hoop. As the entire weight of the tool string is carried, in turn, by the swivel thrust bearings, these latter must be most carefully lubricated to prevent undue wear. The prevailing loads increase in proportion to the depth of the well.

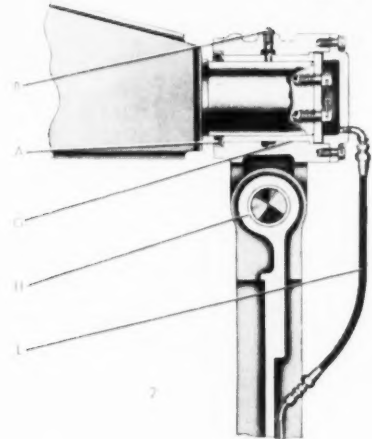
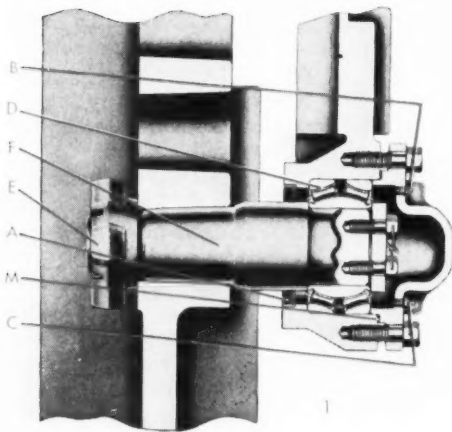
It is through the swivel that the slush fluid is admitted to flush cuttings from the hole and enables free rotation of the drill. Suitable piping and connections are installed to admit this fluid at the top and to direct it downward through the drill pipe.

The prevailing loads require a ball or roller type of swivel thrust bearing equipped with an oil reservoir of from five to thirty gallons capacity. Oil is circulated by splash induced by the rotation of the unit. To meet these loads considerable body or viscosity is essential, the range normally being from 160 to 200 seconds Saybolt Universal at 210 degrees Fahr.; oils within the lighter range are suitable to smaller units.



Courtesy of Emsco Manufacturing Company

Figure 10—Features of an EMSCO swivel as they relate to lubrication. A—indicates the pressure grease fitting; B—shows the oil seals; C—the radial thrust bearing; D—the main bearing; E—the oil reservoir and F—the radial roller bearing.



*Courtesy of Oil Well Supply,
Division of United States Steel Corporation*

- A. Oil Seal
- B. Pressure Relief Fitting
- C. Grease Fitting
- D. Spherical, Self-aligning, Adjustable Roller Bearings.
- E. Lug-Type Nut
- F. Tapered Wrist-Pin
- G. Bronze Bushing
- H. Self-lubricating Bronze Bushing
- J. Machined Saddle-Bearing Support
- K. Reversible Saddle-Bearing Support
- L. Grease Lubrication to Upper-Pitman Bearing
- M. Shims

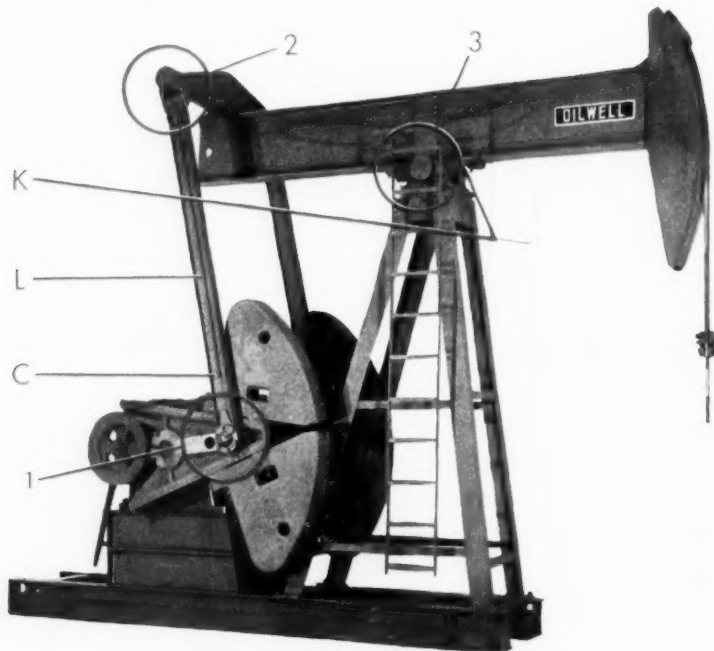
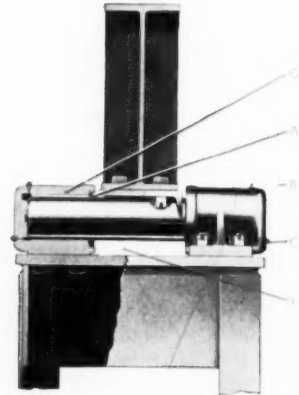


Figure 11—Bearing and lubrication details for "OILWELL" pumping unit.

LUBRICATION

CHAINS AND SPROCKETS

Chain drives and sprockets serve as the power take-off from the oil-field steam engine. Where the gas or Diesel engine is used, however, a gear case or transmission is an added necessity, connected to the draw works through a Vee-belt or chain drive.

Drive chains of the roller type were used in the early development of cable tool drilling. When rotary drilling came in, chain design was given renewed attention. Improved types of roller mechanisms resulted, heat treated alloy steels of high breaking strength were used, and later the silent type of chain became applicable.

Throughout this development and application of chain designs to oil field equipment the builders had to consider load conditions. As strength and durability have increased so has the demand for more positive lubrication. The rugged nature of the roller chain, particularly where built with specially designed pins and bushings, proved it to be especially adapted to such conditions. While improving surface finishes the builders also improved lubrication by creating a design more capable of retaining lubricant.

Silent chains are well adapted to the variety of intricate power transmission work involved in the oil fields. Where properly lubricated they will also

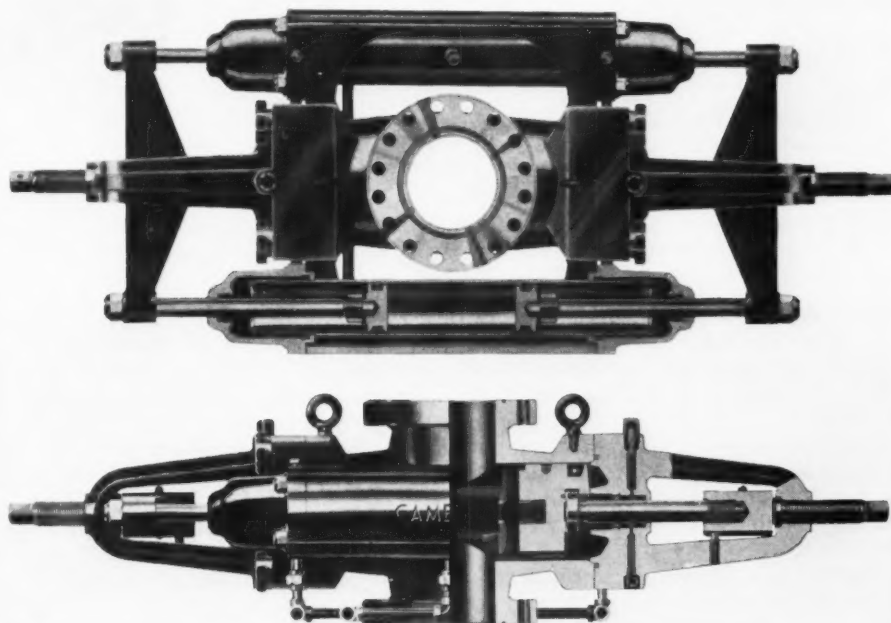
develop but little wear. Usually they are provided with suitable housings and means for automatic circulation of lubricant, as a result cleanliness is maintained.

Lubrication Requirements

Effective lubrication of any oil-field driving chain installation requires that the operating conditions be carefully considered. These include the load, speed, clearances and the extent to which bending or articulation may occur. Each will have a direct bearing upon the ultimate performance which can be expected from the lubricant. Wherever chains can be housed in oil-tight casings, the problem becomes materially simplified, for contamination of lubricant is prevented and lighter bodied products can be used.

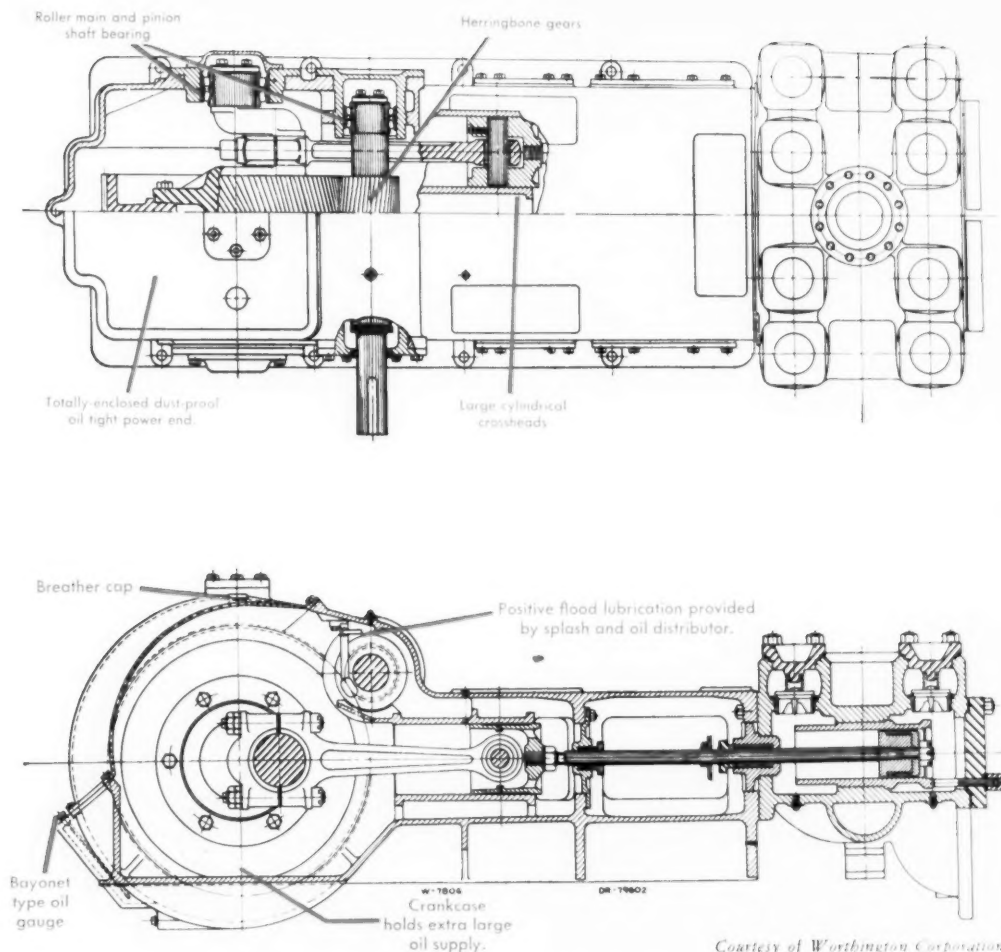
Load is a serious factor wherever a chain may be subjected to sudden starting or stopping. This causes severe shock on the chain parts. A lubricant of sufficient body (within the limits of its ability to penetrate) will serve as a buffer or shock absorber within the clearance spaces.

Speed in turn must be considered since it involves the frequency at which shocks may occur when the chain links engage with the teeth of the sprockets. Obviously, as speeds increase, the shocks



Courtesy of Cameron Iron Works, Inc.

Figure 12—Top and cross-sectional views of a CAMERON Blowout Preventer. This device is advantageous in the safe drilling of deep high pressure wells. Well pressure is utilized in effecting a ram closure and maintaining a seal. Quick ram change and high closing ratio are outstanding features.



Courtesy of Worthington Corporation

Figure 13 — Top and side view sections of a WORTHINGTON horizontal duplex power pump for oil field service. Details pertinent to lubrication and protection of the gears and bearings are indicated in red.

on each chain link will be more frequent. This will impose a more severe load on the film of lubricant on the contact surfaces which may lead to actual rupture of this film or to its being squeezed out to excess.

Bending or articulation imposes wear not only on the actual points of contact between the teeth and chain but also on the link pin bearings. Correct chain design eliminates this tendency by confining the necessary rubbing and rolling to the joints themselves. It is, however, almost impossible to eliminate external wear especially on exposed chains. Here again, effective lubrication becomes a factor. Penetration of lubricant is, of course, influenced by the amount of clearance existing between the component parts of the chain. If these clearances are low or cold starting is required, the lubricant should be of lighter body.

To meet these conditions in average oil-field operation, it has been found expedient to use straight mineral lubricants. Where gear and chain assemblies are properly housed, the minimum viscosity range should normally be around 500 seconds Saybolt Universal at 100° Fahr. According to temperature conditions this may range up to perhaps 900 seconds. Under some conditions the automotive type of straight mineral gear lubricant will perform satisfactorily. Under others, involving perhaps higher temperatures with normal clearances or heavy duty link mechanisms, it may be advisable to go as high as 1000 seconds Saybolt Universal at 210° Fahr.

Relubrication and Cleaning

The operating conditions will influence the frequency at which oil-field driving chains should be

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cleaned and relubricated. Where contamination by dust and dirt may not be extreme it will perhaps only be necessary to renew lubricant on exposed chains at weekly to semi-monthly intervals. Perhaps every three months it may be advisable to wash the chain surfaces and link mechanisms as thoroughly as possible with kerosine. Chain manufacturers recommend entire removal of the chain from the assembly and complete immersion in a bath of kerosine. This is especially advisable with silent chains by reason of their intricate link mechanism.

The heavy duty exposed roller type of chain requires careful attention wherever it may be exposed to the weather and the possibility of contact with considerable dust and dirt, particularly under dust storm conditions. The cost of chain replacement may become a serious item if lubrication is neglected, for any chain failure in connection with

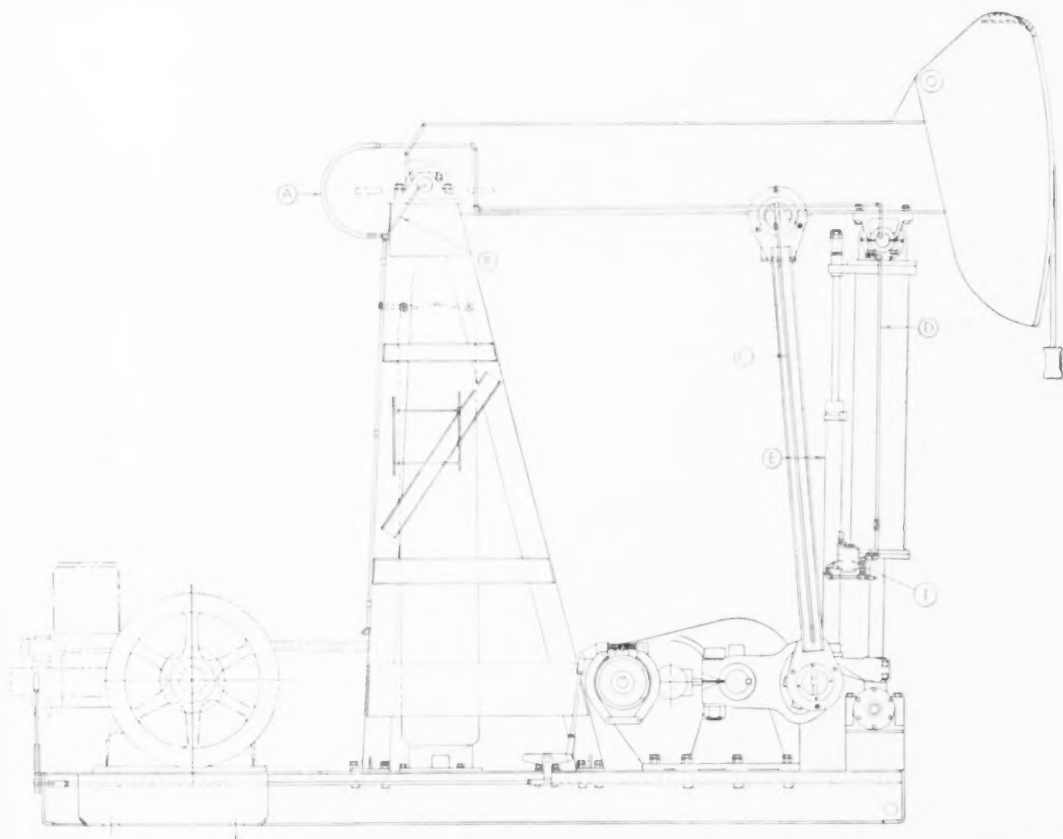
the draw works would cause work stoppage.

ROTARY DRILLING REQUIRES PUMPS

Heavy duty pumps are required in rotary drilling to circulate the drilling mud. Mud serves to:

- (a) Cool the bit.
- (b) Remove cuttings from the hole, to prevent clogging the drill.
- (c) Hold cuttings in suspension by gelling when pumps are stopped.
- (d) Control subsurface movement of high pressure zones by adding weighing materials.
- (e) Plaster the walls of a hole with a thin impervious layer which prevents losses of mud or water to the formations.

Later, the cuttings should drop out when the



Courtesy of The Parkersburg Rig and Reel Company

Figure 14 — Side elevation of a PARKERSBURG oil field pneumatic pumping unit. A — indicates lubricating line to the upper cylinder bearing; B — is the line to the Samson post bearing; C — the pitman yoke bearing lubricating line; D — the oiler line to main cylinder; and E — the air compressor lubricated by a Manzel oiler; and I — the oiler assembly for the compressor lubricating system. Location of lubricating accessories close to floor level enables safe re-lubrication of all parts.



Courtesy of Link-Belt Company

Figure 15—A typical LINK-BELT vibrating screen in operation reclaiming mud for re-use in oil well drilling. See details of vibrator mechanism in Figure 16.

mud reaches the surface pits for reclaiming prior to reusage. It is of further advantage to remove sand, shale and rock particles in order to protect the working elements of the pumping system. An excess of abrasive matter would wear the pump liners and affect the valve motions. Shaking screens and settling pits clean up the mud and prevent pump wear.

Pump Design

The reciprocating duplex piston or poppet valve type pump is best suited to the handling of the average mud or slush employed in rotary drilling. High pressures usually are necessary, ranging from 1800 to 2000 pounds per square inch for deep well drilling, although the modern heavy duty slush pump will be capable of functioning up to 2500 pounds safe working load. The drive will depend upon the design, and type of power take-off. Where steam power is available direct connected steam pumps are used. On power rigs chain and sprocket drives or v-belt drives are used.

The driving gear or power end of an oil-field

pump must be protected. Accordingly, these mechanisms are housed against entry of slush, mud or other foreign matter in a suitable base casting, covered with a sheet metal hood. By gasketing the joints, and adding the further provision of a mud stop head next to the fluid end stuffing box to divert any leakage of mud or slush fluid past the stuffing box into the sump below, contamination of lubricants is effectively prevented. An oil stop head also prevents loss of lubricant along the piston rod.

Cleaning Rotary Mud or Slush

Drilling mud is recirculated in all cases as it is usually an expensive item due to the cost of the chemicals and other materials which it contains. As already stated, the mud must be cleaned before recirculation. A shaker or vibrating screen is used to remove the cuttings from the hole. This is a self-contained unit consisting of a screen deck carried in a suitable box. Vibration is brought about by a rotating shaft, an arrangement of out-of-balance pulleys and a spring assembly. The screen

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is normally set in an inclined position to allow the drilling mud to flow over the screen deck, which removes shale and rock particles, discharging same into a reject pit, the fluid meanwhile passing through the screen for delivery back to the slush pump via the settling pit for removal of fine sand. Such a screen serves an added purpose in that it aids in freeing the mud from gas, thereby helping the pumps to maintain their output.

Lubrication of a vibrating screen is largely confined to the rotary shaft which turns over about 1800 r.p.m. This shaft is normally mounted in sealed anti-friction bearings provided with means for pressure grease lubrication. These bearings are pre-lubricated before leaving the factory. Later in service re-lubrication about once a month is advisable.

STEAM POWER

With the source of fuel immediately available in the form of natural gas or crude oil, steam became the most suitable medium for power when the oil fields were being developed. Pictures of steam boilers being hauled into the fields by long teams of horses still are vivid to many. Steam engines and pumps also are relatively simple in design — another factor which favored steam.

The conditions of service immediately caused thought to be given to steam cylinder lubrication. Builders and operators alike took into consideration that very often the moisture content of the steam was higher than in any other type of service, for the steam is utilized under condensing conditions most of the time.

Quite naturally, exposure of the entire power plant is the primary cause. Oil-field boilers and en-

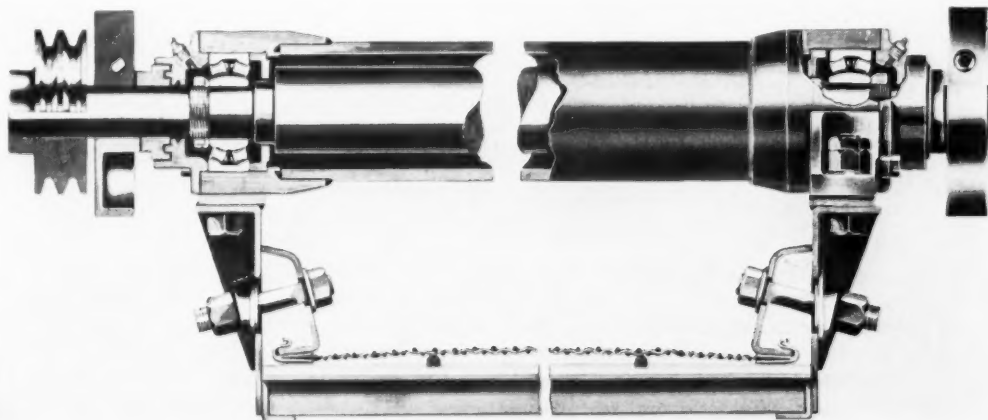
gines are seldom sufficiently housed to enable even limited control of room temperatures as is usual practice in an industrial plant. Furthermore, high steam pressures usually are not necessary — from 100 to 350 pounds gauge is a fair average. So conditions of steam cylinder lubrication prevail which only can be met with a highly compounded cylinder oil. Furthermore, this must be a rugged oil which will form a film capable of resisting the wearing effect of foreign matter.

Effect of Water Conditions

The water available for steam boilers in many oil-field areas is relatively hard, often containing suspended sediment. Foreign matter of this nature is abrasive and if carried over to the engines with the steam, it can cause abnormal wear of the cylinder walls and valve surfaces unless they are protected by a tough durable film of emulsifiable steam cylinder oil.

The horizontal two-cylinder engine equipped with a slide or piston valve is usually the most dependable machine under these conditions. Such an engine is particularly applicable for furnishing power to the draw works and pumps through a sprocket or chain drive, for it can turn out power almost regardless of the operating conditions. With the crankcase and external parts entirely enclosed bath or splash lubrication is practicable. The design also prevents entry of mud, rain and dust.

In such an engine the connecting rod bearings and other external parts can be lubricated by a good 300 to 600 viscosity engine oil according to the atmospheric conditions. Naturally, in the northern or western oil fields a lighter oil may be advisable,



Courtesy of Link-Belt Company

Figure 16—Vibrator mechanism for a LINK-BELT screen showing bearings and relation to screen box. Self-aligning roller bearings are grease-lubricated and fully protected from abrasive dust and corrosive moisture by labyrinth seals and steel housing. Mechanism easily dismantled by removing four bolts and without disturbing installation.



Courtesy of Lufkin Foundry and Machine Company

Figure 17—A LUFKIN oil field pumping unit powered by LUFKIN-COOPER-BESSEMER gas engine. Identity of various bearings and center-line features are shown at top right. Placing the tail bearing under the beam eliminates vibration in the walking beam. Note also details of the oil-lubricated pitman bearing at left. The dust-proof nature of construction eliminates chance of oil contamination and reduces need for costly repair. The manufacturers recommend use of an SAE 140 E.P. lubricant for these bearings. Pour point should be at least 10°F lower than the outside temperature.

especially in winter when the question of fluidity in the crankcase is important.

Valve and cylinder lubrication with a suitably compounded steam cylinder oil in turn is accomplished by hydrostatic or mechanical force feed lubricators with suitable leads to the steam line or intake manifold at the steam chest. Line condensation is reduced by careful insulation of all steam piping and exposed boiler and engine parts. This insulation must be properly maintained to be most effective. Steam chest temperatures are, of course, influenced by the boiler pressure. The higher the

latter, the higher will be the temperature. In addition, super-heating, if applied, will increase the steam temperature that much higher, although superheaters are not favored due to the extra weight that would have to be moved from location to location. The practical limitations outweigh the possible benefits.

It is not difficult to maintain proper engine cylinder lubrication under high steam temperatures. But when high temperatures are accompanied by moisture developed through line condensation or priming, lubrication becomes more difficult; hence

LUBRICATION

the advisability of reducing condensation as much as possible. Normally a compounded steam cylinder oil will meet these conditions most effectively, the amount of compound or fixed (fatty) oil being dependent upon the amount of moisture in the steam. For the more usual condition of comparatively wet steam a medium viscosity cylinder stock compounded with around six to eight per cent of fatty oil will function effectively.

Condensing engines are used in brackish water areas where fresh water might have to be hauled in for long distances. It is quite common to have a condensing system setup on drilling barges. Under such conditions means for removing cylinder oil from the exhaust must be provided.

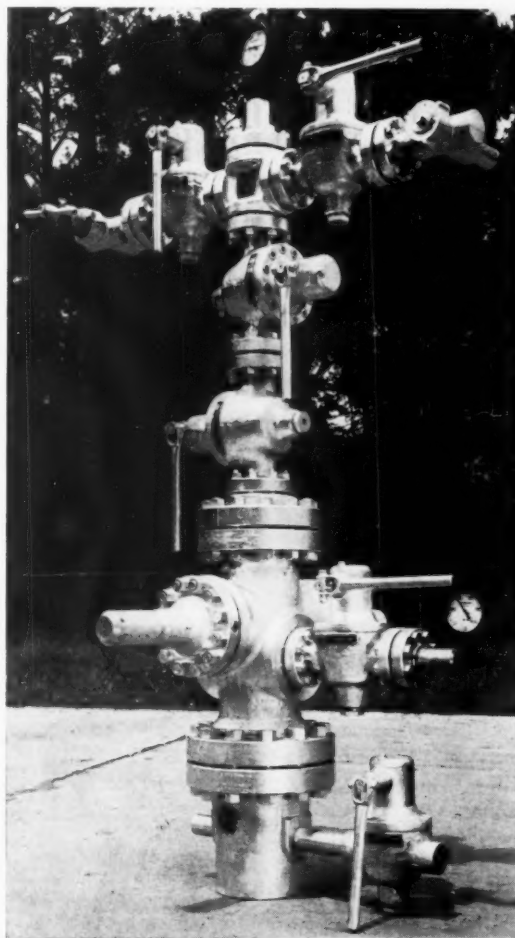
Cylinder liner wear is not serious in the vertical, twin-cylinder steam engine when applied to oil-field service. Steam cylinder lubrication in the vertical type engine will differ but little, otherwise, from that of a horizontal engine. The primary purpose is to use an oil containing sufficient compound to lather readily with the moisture content of the steam, and of sufficient viscosity to meet the prevailing temperature conditions. Any such oil will be comparatively heavy in body, and hence may flow with difficulty in cold weather. Where winter-time temperatures may not be extreme as in the Gulf Coast area or California, the question of fluidity is not a problem. In central or northern fields, however, methods of lubricator protection may have to be studied to insure against congealment of the oil at low temperatures for this might easily decrease the amount of oil delivered to the cylinders, or even prevent flow entirely. Heating coils in the oil reservoirs of mechanical force feed lubricators are useful under such conditions.

DIESELS AND GAS ENGINES

Pipe line extensions and the availability of distillate and gas fuels promoted the popularity of the oil-field diesel and gas engine. This trend was hastened by the necessity for self-powered pumping units. The gas engine quite naturally proved its value as a medium for utilizing the natural gas which not so many years ago was regarded as a necessary evil. The gas engine is perhaps the more flexible in application because it can burn practically any type of natural or refinery gas. Certain designs also can be readily converted to burn distillate oils or gasoline. The diesel, on the other hand, functions best on a heavier distillate fuel or high gravity crude oil. The normal oil field diesel or gas/gasoline engine is a vertical unit which may operate at either high or low speed depending upon its design. It will require about 150 barrels of water per day as compared with a steam rig which will require about 1000 barrels of water daily. This is a definite advantage in poor water localities.

The internal combustion engine in oil-field service may have to function at any time under adverse conditions depending on the geographical location. Summer operation in the South or Southwest may involve atmospheric temperatures well over 100°F. with very sharp drops (of 30 to 50 degrees) at night. In some localities the atmospheric dust content may be very high.

The burning of natural or casinghead gas can present another condition which is entirely foreign to other types of internal combustion engine fuels: entrained air. Air in casinghead gas used to be one of the possible sources of trouble in the operation of a gas engine, due to the detrimental effect on cylinder lubrication. Air in such gas usually resulted from defective casingheads which would permit air leakage in variable amounts into the lines when vacuum was drawn on the wells. Gas engines op-



Courtesy of Cameron Iron Works, Inc.

Figure 18—A good example of a typical CAMERON christmas tree manifold.

erating on air-contaminated fuel are subject to excessive air which can cause pre-ignition and over-heating. This can become so severe as to destroy the lubricating film on the cylinder walls and lead to severe ring and liner wear. Fortunately this is not much of a problem today as vacuum equipment is no longer used to any extent to obtain production.

Contaminated Cooling Water Also a Factor

Unsuitable cooling water is another frequent cause of difficulty in the operation of oil-field diesel and gas engines. In some areas, the water available may be very hard and have a tendency to deposit scale and form an insulating coating in the water jackets. This will result in insufficient cooling, and when it develops in an engine already subjected to abnormally high operating temperatures, it may become another cause of pre-ignition, back-firing, sludging, high oil temperatures, stuck rings and destruction of the lubricating film on the cylinder walls. Adequate cooling is most essential in the interest of maintenance of positive lubrication.

Engine Deposits

Formation of deposits in the combustion chamber of the gas engine occurs in much the same manner as in the diesel. There will be but little possibility, however, of this being aggravated by the type of gas used unless the gas is dirty or has a high dust content, when the same results would occur as when liquid fuel is subjected to incomplete combustion, i.e., fouling and sticking of the valves, and possibly increased cylinder wear due to abrasion and stuck piston rings. The increased contamination of the crankcase oil from the combustion chamber together with the increased temperature can cause undue oxidation and sludging with subsequent

damage to the bearings. Prevention of deposits throughout the engine as well as in the cooling water jacket can be assisted by using treated cooling water whenever possible.

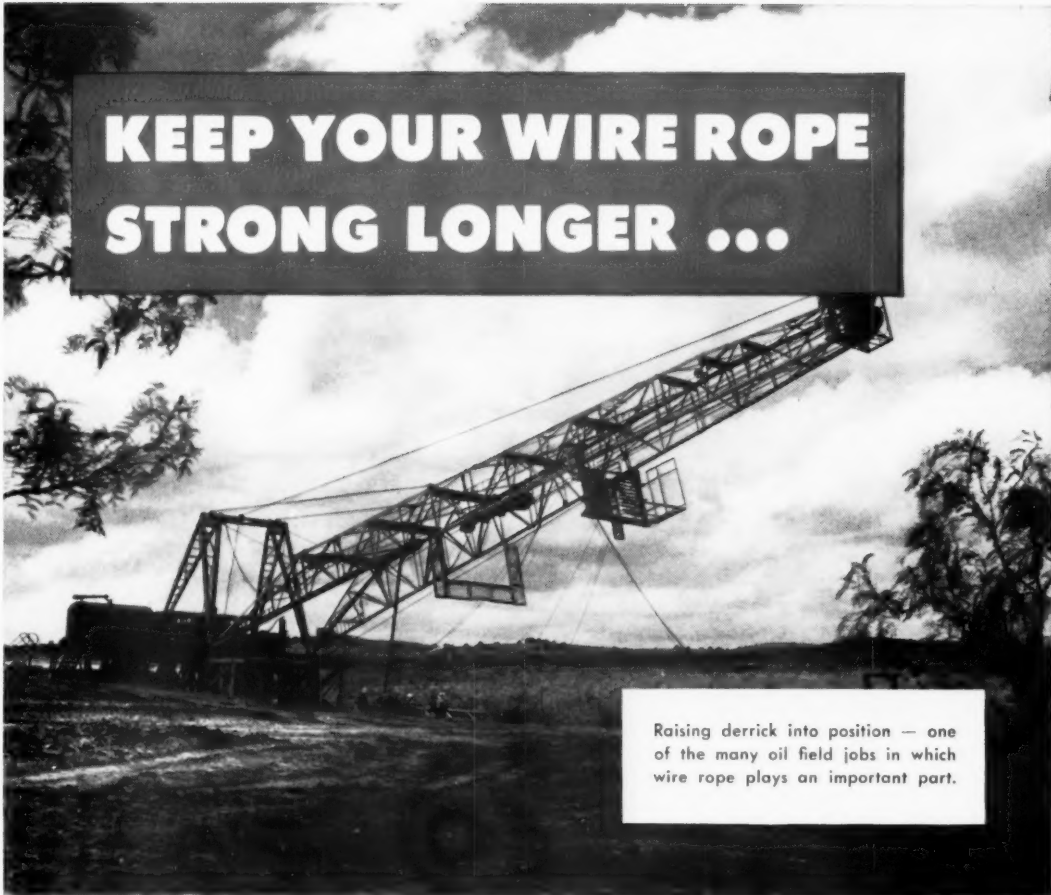
CONCLUSION

When the petroleum industry was going through that most important transition in its early history — the kerosine to gasoline phase — the machinery of production was taking shape as the genesis of one of the major industries of the world. All this has taken place in but a little over the past fifty years. Other industries have gone through so-called revolutions — spearheaded by the ingenuity of machinery operators. Greater output with less manual effort was the objective.

It was a foregone conclusion that these machinery developments in transportation and other basic industries would spur the petroleum industry on to more intensive study of lubricants — as major products of raw crude oil. To produce the required volumes of the latter, production machinery had to function effectively. Drilling and pumping in the early days of our industry were carried out with not too much thought being given to lubrication. Today things are changed. Oil field machinery is precision-built; bearings, gears and chains are enclosed; ball and roller bearings are used more and more extensively; lubricants are applied by circulating systems, or centralized pressure. It is a dream of the lubrication engineer which has actually come true: machinery operating under adverse service conditions, protected so effectively by lubrication design that the operators can almost forget this need (except to keep the systems filled with the proper lubricants) and devote their energies to producing the wells. We hope this article gives an insight into the petroleum industry's idea of the importance of lubrication within its own confines.



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